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百合科六属十五种植物的细胞学研究

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A CYTOLOGICAL STUDY OF FIFTEEN SPECIES IN SIX GENERA OF LILIACEAE FROM YUNNAN

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摘要 本文对云南西北部百合科6属15种的染色体和核型进行了报道。(1) *Clintonia udensis* Trautv. et Mey 间期核属于浓密分散型，前期染色体属于渐变型，分裂中期体细胞染色体 2n=14=8m+4sm+2st (2SAT)，核型不对称性属于2A型；(2) 鹿药属四个种间期核属于复杂中央微粒型，前期染色体属于中间型，分裂中期体细胞染色体分别为 *Smilacina henryi* (Baker) Wang et Tang, 2n=36=12m+16sm+6st+2t (2SAT)，核型不对称性属于2C型；*Smilacina fusca* Wall., 2n=36=14m (2SAT)+12sm+10st (2SAT)，核型不对称性属于2B型；*Smilacina tatsienensis* (Franch.) Wang et Tang, 2n=36=22m+2sm+2st(2SAT)，核型不对称性属于2C型；*Smilacina atropurpurea* (Franch.)Wang et Tang, 2n=36=18m+6sm (2SAT)+12st，核型不对称性属于2C型；(3) 黄精属四个种的间期核属于复杂中央微粒型，前期染色体属于中间型，分裂中期体细胞染色体分别为 *Polygonatum kingianum* Coll. et Hesml., 2n=30=12m (2SAT)+6sm+1st+2t，核型不对称性属于2C型；*Polygonatum cirrhifolium* (Wall.) Royal, 2n=30=10m+4sm+12st+4t，3C型；*Polygonatum curvistylum* Hua, 2n=78=24m (2SAT)+14sm (6SAT)+40st，核型不对称性属于3C型；*Polygonatum cathcartii* Baker, 2n=32=12m+6sm+10st+2t+2bs，核型不对称性属于2C型；(4) 百合属，假百合属，豹子花属三个属的间期核和前期染色体形态相似，都属于复杂中央微粒型，前期染色体属于中间型，分裂中期体细胞染色体分别为 *Lilium henricii* Franch, 2n=24=2m (2SAT)+2sm+10st+10t，核型不对称性属于3A型；*Lilium bakerianum* Coll. et Hesml. var. *rubrum* Stearn, 2n=24=4m (2SAT)+10st+10t (2SAT)，核型不对称性属于3A型；*Nomocharis bilouensis* Liang 2n=24=2m (2SAT)+2sm+12st+8t，核型不对称性属于3A型；*Nomocharis pardanthina* Franch., 2n=24=4m (2SAT)+12st (2SAT)+8t，核型不对称性属于3A型；*Nomocharis sauluensis* Balf. f., 2n=24=4m (2SAT)+10st (2SAT)+10t，核型不对称性属于3B型；*Notholirion campanulatum* Cotton et Stearn 2n=24=2m (2SAT)+2sm+14st (2SAT)+6t，核型不对称性属于3A型。

关键词 百合科；七筋姑属；鹿药属；黄精属；豹子花属；百合属；假百合属；核型；

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Abstract Fifteen species in six genera of the family Liliaceae were karyomorphologically studied. They share the complex chromocenter type of the resting nuclei and the interstitial type of the prophase chromosomes in somatic cells except that Clintonia udensis Trautv. et Mey is of the densely diffuse type and gradient type respectively. Their karyotype formulas are listed as follows: *Clintonia udensis* Trautv. et Mey, 2n=14=8m+4sm+2st (2SAT), belongs to 2A type; *Smilacina henryi* (Baker) Wang et Tang, 2n=36=12m+16sm+6st+2t (2SAT), 2C type; *Smilacina fusca* Wall., 2n=36=14m (2SAT) +12sm+10st(2SAT), 2B type ; *Smilacinata tsienensis* (Franch.) Wang et Tang, 2n=36=22m +2sm+2st(2SAT), 2C type; *Smilacina atropurpurea* (Franch.) Wang et Tang, 2n=36=18m+6sm(2SAT) +12st, 2C type: *Polygonatum kingianum* Coll, et Hesml., 2n=30=12m(2SAT) +6sm+1st+2t, 2C type; *Polygonatum cirrhifolium* (Wall.) Royal, 2n=30=10m+4sm+12st+4t, 3C type; *Polygonatum curvistylum* Hua, 2n=78=24m (2SAT)+14sm (6SAT)+40st, 3C type; *Polygonatum cathcartii* Baker, 2n=32=12m+6sm+10st+2t+2Bs, 2C type; *Lilium henricii* Franch., 2n=24=2m(2SAT)+2sm+10st+10t, 3A type; *Lilium bakerianum* Coll. et Hesml. var. *rubrum* Stearn, 2n=24=4m (2SAT) +10st+ 10t (2SAT), 3A type; *Nomocharis bilouensis* Liang, 2n=24=2m (2SAT) +2sm+ 12st+8t, 3A type; *Nomocharis pardanthina* Franch., 2n=24=4m (2SAT) +12st (2SAT)+8t, 3A type; *Nomocharis sauluensis* Balf. f., 2n=24=4m(2SAT) +10st (2SAT) +10t, 3B type; *Notholirion campanulatum* Cotton et Stearn 2n=24=2m(2SAT)+2sm+14st(2SAT)+6t, 3A type.

Key Words *Liliaceae*; *Clintonia*; *Smilacina*; *Polygonatum*; *Lilium*; *Nomocharis*; *Notholirion*; Karyotype

Introduction

The Hengduan Mountains lies in the east of the Himalayas. The intense mountain-making movements resulted in the complexity of the topography and climate, i. e. the vertical climatic zonation is remarkable and the natural geographical conditions are strikingly differentiated, so that the floristic elements are abundant. In this area there are not only many ancient species and relic plants but also many differentiating groups and thus it is the center of distribution and differentiation of morden plants. Plants of the family Liliaceae are very rich where there are abundant wildy distributed species and endemic species. Hence, study the variation in the cytology, orphology and habitat, and their relationships, we expect to explore the formation and developement of the flora and species differentiation. The present paper is a part of the series of such works.

Materials and methods

The locality of each species studied here is shown Table 1. The vouchers are

Table 1　The materials studied in this work

Taxon	Locality	Altitude (m)	Voucher
Clintonia udensis Trautv. et Mey	Yunlong (云龙)	3 300	Gongxun－01023
Smilacina henryi (Baker) Wang et Tang	Dali (大理)	3 200	Gongxun－01097
S. atropurprues (Franch.) Wang et Tang	Yunlong(云龙)	2 800	Gongxun－01032
S. fusca Wall.	Yunlong (云龙)	2 800	Gongxun－01028
S. tatsienensis (Franch.) Wang et Tang	Dali (大理)	3 200	Gongxun－01098
Polygonatum kingianum Coll. et Hesml	Kunming(昆明)	2 100	Gongxun－01064
P. cirrhifolium (Wall.) Royle	Yunlong (云龙)	2 900	Gongxun－01035
P. curvistylum Hua	Dali (大理)	2 800	Gongxun－01051
P. cathcartii Baker	Gongshan (贡山)	2 600	Gongxun－01126
Lilium henricii Franch.	Lijiang (丽江)	2 800	Gongxun－01145
L. Bakerianum Coll. et Hesml var. *Rubrum* Stearn	Dali (大理)	3 200	Gongxun－01012
Nomocharis bilouensis Liang	Lijiang (丽江)	3 400	Gongxun－01143
N. pardanthina Franch.	Dali (大理)	3 200	Gongxun－01010
N. sauluensis Balf. f.	Yunlong (云龙)	3 100	Gongxun－01021
Notholirion campanulatum Cotton et Stearn	Dali (大理)	3 200	Gongxun－01129

deposited in Botanic Garden of Kunming Institute of Botany, Academia Sinica. For observations of somatic chromosomes, growing root tips were used. They were pretreated with aqueous solution of 0.1% colchicine at 20 ℃ for 2 hours before they were fixed in 1:3 acetic alcohol at 4 ℃ for 20 minutes. The root tips were hydrolyzed in 1:1 mixture of 45% acetic acid and 1 mol/L HCl at 60 ℃ for 30 seconds and then stained and squashed in 1% aceto-orcein. The chromosome classification follows Levan et al. (1964), the karyotype classification follows Stebbins (1971) and chromosome morphology at resting stage and prophase are classified and described according to Tanaka's nomenclature system (1971, 1977). The somatic chromosomes, karyotypes are presented in Plate. 1 — 7, and the idiograms in Fig. 1.

Results and discussions

1. Clintonia udensis Trautv. et Mey. is karyomorphologically characterized by the densely diffuse type of the resting nucleus, and the mitotic prophase nuclei belongs to the gradient type. The karyotype is formulated as $2n = 14 = 8m + 4sm + 2st$ (2SAT). The chromosomes in relative length range from

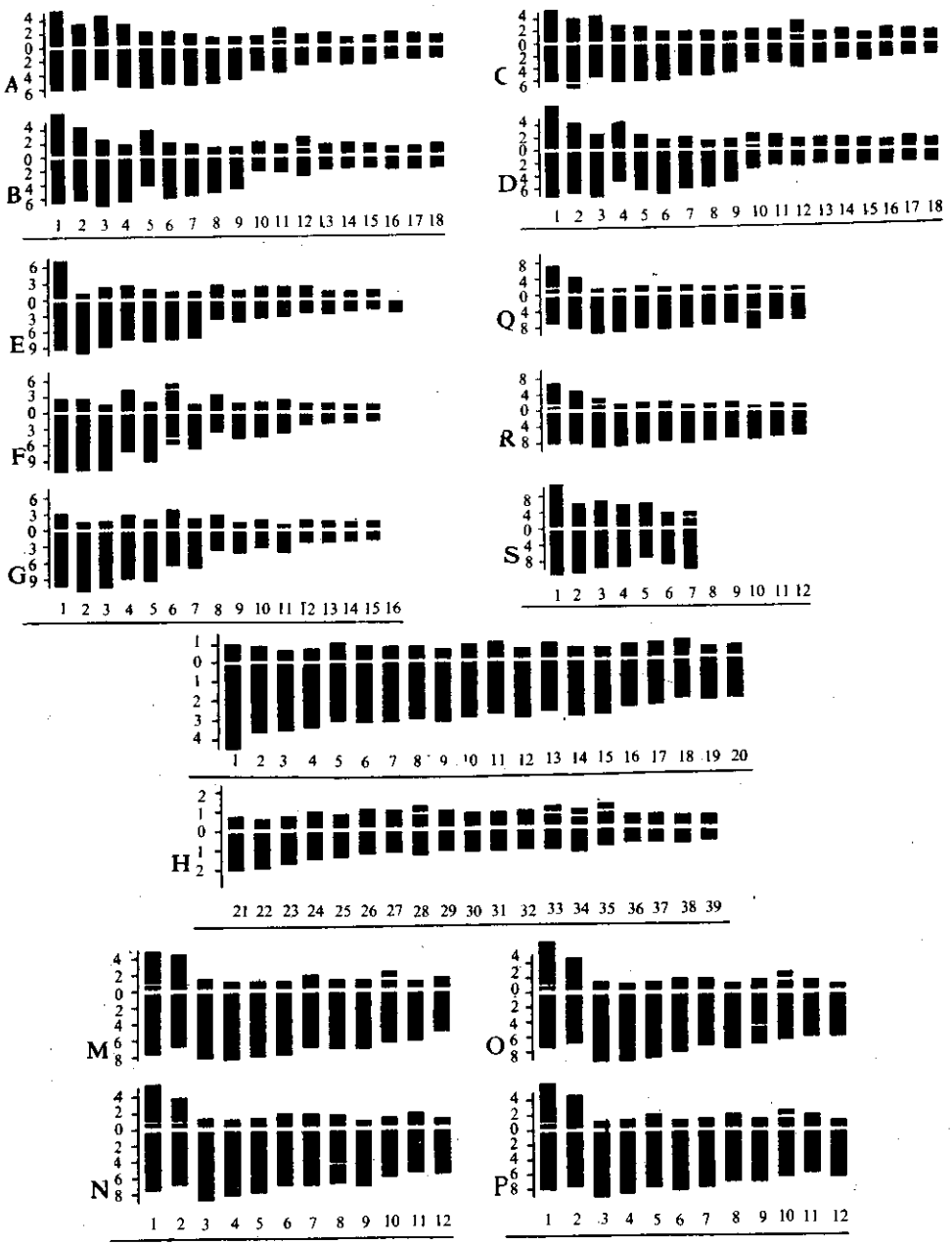

Fig. 1 Idiograms

A: Smilacina henryi. B: *S. tatsienensis*. C: *S. fusca*. D: *S. atropurpurea*. E: *Polygonatum cathcartii*. F: *P. Kingianum*. G: *P. cirrhifolium*. H: *Polygonatum curvistylum*. M: *Nomocharis pardantharis*. N: N. *bilouensis*. O: *N. saluensis*. P: *Notholirion campanulatum*. Q: *Lilium henricii*. R: *L. bakerianum* var. *rubrum*. S: *Clintonia udensis*.

20.66 to 11.10, with the ratio of the longest to the shortest 1.86. Four out of 14 chromosomes in the complement have arm ratios over 2.00. Thus, the karyotype asymmetry could be categorized as Stebbins' " 2A type". The 7th pair of chromosomes have satellites on the short arms.

There are five species and one variety in the genus *Clintonia*, in which *C. andrewsisns* Torrey, *C. umbellutala* (Michx.) Morong, *C. borealis* (Ait.) Raf. and *C. uniflora* (Menzies ex Schultes) Kunth, are distributed in North America According to the earlier investigators, the 2n=28 cytotype was commonly found (Utech et al., 1975) in the genus, but a few authors reported 2n=28 or 2n=32 for the same species from different localities (Love A, Love D, 1966; Utech 1972). In the earlier studies, x=14 was established as the basic chromosome number of the genus. *C. udensis* and its variety *alpina* are distributed in east Asia, the chromosome numbers of the PMC and somatic cell of *C. udensis* var. *alpina* were *n=14* (Hara et al. 1963, 1964), 2n=28 (Pahuja et al. 1971) respectively. Utech et. al. (1975) studied *C. udensis* Trautv. et Mey. from Japan, and found 2n=28, but Sokolovskaya (1966) found 2n=14 in the material from U. S. S. R. which was similar to the material studied in this paper from the Hengduang Mountains. We consider, therefore, that x=7 is the basic number of this genus, while those species from North America are polyploids. According to the cytological results reported so far, we speculate that this genus might have originated from the Himalayas, and its present differentiation center should be in North America.

2. Smilacina Desf. The resting nucleus in somatic cells in the four studied species of *Smilacina* are of the complex chromocenter type and the prophase nucleus in mitotic cells studied here are of the interstitial type. The chromosomes at somatic metaphase are bimodal, with nine pairs of long and nine pairs of short ones (if the length of satellite is included in it, the ratio of the longer ones to the shorter ones is 10:8).

(1) *S. henryi* (Baker) Wang et Tang: The karyotype is formulated as 2n=36=12m+16sm+6st+2t(2SAT). The relative lengths of the chromosomes range from 10.71, to 2.67 with the ratio of the longest to the shortest 4.01. Five percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as "2C type". The 11th pair of chromosomes each have a satellite on the short arm.

S. henryi from Shaanxi Province was found to be diploid, with karyotype formula 2n=36=16m+10sm+10st(2SAT) (Hong and Zhu 1990), which is different from what is reported in this paper except the position of the satellite. In their report the ratio of longest/shortest chromosomes was 3.80, and the ratio of the

shortest among the longer group to the longest in the shorter group was 1.42, but it is 4.01 and 1.28 respectively in the present paper. In addition, the karyotype in this paper has a pair of acrocentric chromosomes (if the short arm of this pair is regarded as an intercalary satellite, it would be subtelocentric).

(2) *S. tatsienensis* (Franch.) Wang et Tang: The karyotype is formulated as 2n=36=22m+2sm+12st (2SAT). The relative lengths of the chromosomes range form 12.31 to 2.79, with the ratio of the longest to the shortest chromosome 4.41 thirty-nine percent of chromosomes have arm ratios over 2.00, and thus, the karyotype asymmetry could be categorized as " 2C type". The 12th pair of chromosomes have satellite on their short arms.

The material from Sichuan Province was reported having karyotype 2n=36=16m+10sm+10st (2SAT) (Wang et al. 1990), in which there were ten pairs of longer and eight pairs of shorter chromosomes. The ratio of the shortest in the longer group to the longest in the shorter group was 1.33, and the ratio of the longest to the shortest chromosome was 4.33, which is approximate to the ratio of 1.47 and 4.41 reported in the present paper. However, the position of the satellite is different from each other, the material from Sichuan were of a satellite in the 10th pair of chromosomes and a second construction in its homologous chromosome, showing soms heterozygosity. A comparison of the two karyotype formulas shows that the median chromosomes and submedian ones have different numbers, which may be caused by measurement and calculation.

(3) *S. fusca* Wall: The karyotype is formulated as 2n=36=14m (2SAT)+12sm +10st (2SAT). The relative lengths range from 9.92 to 2.99 with the ratio of the longest to the shortest 3.32. The ratio of the shortest in the longer group to the longest in the shorter group is 1.21. Five percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry belongs to " 2B type". The 2nd and the 12th pairs of chromosomes have satellites on their short arms.

The chromosome numbers of this species were previously reported having 2n=36 by Kumar (1959), 2n=72 (Kurosawa 1966; Sharma 1970) and 2n=28, 66, 72 (Sharma 1970). Based on the earlier investigators, the material from East Himalayas had 2n=72 by Mehra and Sachdeva (1979). What reported in this paper is the same as Kumar's.

(4) *S. atropurpurea* (Franch.) Wang et Tang: The karyotype is formulated as 2n=36=18m+6sm(2SAT)+12st. The relative lengths of chromosomes range from 12.41 to 2.77 with the ratio of the longest to the shortest 4.01. The ratio of the shortest in the longer groups to the longest in the shorter group is 1.40. thirty-nine percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as " 2C type". The 10th pair of

chromosomes each has a satellite on the short arm.

The chromosome number of PMC's of its closely related specie *S. purpurea* Wall. from East Himalayas, was examined to be n=18 by Mehra and Pathania (1960). Later, in the materials from Simla and Kumaon of India, 2n=36 chromosomes were observed (Mehra & Sachdeva 1976), in which there were 10 pairs of longer and 8 pairs of shorter chromosomes. Among the longer chromosomes, there were two pairs of metacentric, three pairs of submetacentric and five pairs of subtelocentric chromosomes. On the other hand, among the shorter chromosomes, there were three pairs of metacentric, three pairs of submetacentric and two pairs of subtelocentric chromosomes. Comparing the karyotype reported by Mehra et al. with that in this paper, it was found that the shorter chromosomes in the two karyotypes are different, while their longer chromosomes are similar.

3. Polygonatum Mill. The resting nucleus of somatic cells in the four species of *Polygonatum* are of the complex chromocenter type and mitotic prophase muclei are of the interstitial type, the same as in *Smilacina*, but the heterochromatin density of them are different. The diploids tend to be bimodal, while the long and short chromosomes are not identical among species. Polyploids are not very prominent in this respect, with the relative lengths of chromosomes decreasing gradually from long to short.

(1) *P. cathcartii* Baker: The karyotype is formulated as 2n=30+2Bs=12m+6sm+10st+2t+2Bs. The relative lengths of chromosomes range from 14.85 to 2.11 with the ratio of the longest to the shortest 6.94. There are seven pairs of longer and eight pairs of shorter chromosomes; the ratio of the shortest in the longer group to the longest in the shorter group is 1.42. Five percent of all chromosomes have arm ratios over 2.00, and the karyotype asymmetry could be categorized as "2C type". The number and karyotype of this species are reported here for the first time.

(2). *P. kingianum* Coll. et Hesml.: The karyotype is formulated as 2n=30=12m(4SAT)+6sm+10st+2t. The relative lengths of chromosomes range from 11.73 to 2.12 with the ratio of the longest to the shortest 5.53. There are 11 pairs of longer and four pairs of shorter chromosomes; the ratio of the shortest chromosome in the longer group to the longest one in the shorter group is 1.62. Fourty-seven percent of chromosomes have arm ratios over 2.00, the karyotype asymmetry could be categorized as "2C type". In the karyotype a very rare phenomenon was observed, i. e. both short and long arms of the 6th pair have a satellite.

The chromosome number was found to be 2n=64 by Kumar (1959), while Yang et al. (1988) reported 2n=36, in which there were three pairs of metacentric, six pairs of submetacentric and four pairs of subtelocentric

chromosomes, with no SAT-chromosomes observed; the karyotype asymmetry was categorized as " 3B type". It is very different from the result reported here.

(3) *P. cirrhifolium* (Wall.) Royal: The karyotype is formulated as 2n = 30 = 10m + 4sm + 12st + 4t. The relative lengths of chromosomes range from 11.74 to 2.63 with the ratio of the longest to the shortest 1.42. There are seven pairs of longer and eight pairs of shorter chromosomes; the ratio of the shortest in the longer group to the longest in the shorter group is 1. 42. Fifty-three percent of chromosomes have arm ratios over 2. 00; the karyotype asymmetry could be categorized as "3C type". A second constriction was observed on one long arm of the first pair of chromosomes.

2n = 38 was examined in a material from the Himalayas by Kumar (1959), and 2n = 20 was reported by Wang et al. (1987) in the material from Qinghai. In the latter karyotype, there are 12 pairs of metacentric, 8 pairs of submetacentric chromosomes, with the ratio of the longest/shortest chromosome 2.47, and belonging to " 2B type".

(4) *P. Curvistylum* Hua.: The karyotype is formulated as 2n = 78 = 24m (2SAT) + 14sm (6SAT) + 40st. The relative lengths of chromosomes range 5.13 to 0.97, with the ratio of the longest to the shortest 5.29. Sixty-four percent of chromosomes have arm ratios over 2.00. The karyotype saymmetry could be categorized as " 3C type". The 28st, 33th, 34th and 35th pair of chromosomes each carry satellites on their short arms. Its bimodality is not prominent.

Materials from Sichuan were examined to be 2n = 30 = 14m (2SAT) + 4sm + 10st + 2t , and less frequently 2n = 28 = 14m + 6sm + 6st + 2t, with the ratios of the longest/shortest chromosome 4.27, 4.62 respectively (Yang et al. 1988). The two karypotypes belong to " 3C type".

P. kingianum and *P. cirrhifolium* geographically overlap. It is very difficult to identify the two species by using their morphological characters. *P. kingianum* differ from *P. cirrhifolium* in (1 —)2 — 4(— 6)flowered inflorescence, pendent, long peduncle 1 — 2mm and pedicel 0. 5 — 1. 5mm long; *P. cirrhifolium* has 2-flowered inflorescence over-pedent, peduncle 3-10mm long, and pedicel 3 — 8mm long. Although they both are of 2n = 30, as previously reported, their karyotypes are different. Further research is needed in order to clarify the correlation between karyotype and morphological characters in the two species.

4. Lilium L. The resting nucleus in somatic cells in the following two species are of the complex chromocenter type and the mitotic prophase nucleus are of the interstitial type. In the two karyotypes of the two species, the first pair of chromosomes have interstitial satellites.

(1) *L. hernicii* Franch.: The karyotype is formulated as 2n=24=2m (2SAT) +2sm+10st+10t. The relative lengths of chromosomes range from 10.82 to 6.52 with the ratio of the longest to the shortest 1.66. Ninety-two percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as " 3A type". The 10th pair of chromosomes have a second constriction on their long arms.

(2) *L. bakerianum* Coll. et Hemsl. var. *rubrum* Stearn: The karyotype is formulated as 2n=24=4m (2SAT) +10st+10t (2SAT). The relative lengths of chromosomes range from 12.06 to 6.41 with the ratio of the longest to the shortest 1.88. Eighty-three percent of chromosomes have arm ratios over 2.00, the karyotype asymmetry could be categorized as " 3A type". The third pair of chromosomes have a satellite on their short arm.

5. Nomocharis Franch. The resting nucleus are of the complex chro mocenter type and the mitotic prophase nucleus are of the intersti-tial type.

(1) *N. pardanthina* Franch.: The karyotype is formulated as 2n=24=4m (2SAT) +12st (2SAT) +8t. The relative lengths of chromosomes range from 12.08 to 8.07 with the ratio of the longest to the shortest 1.99; eighty-three percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as " 3A type". The first pair of chromosomes have interstitial satellites and the 10th pair of chromosomes have satellites on the short arms, 6th, 8th, 9th and 10th pair of chromosomes each have a second construction on their long arms.

(2) *N. bilouensis* Liang: The karyotype is formulated as 2n=24=2m (2SAT) +2sm+12st+8t. The relative lengths of chromosomes range from 11.70 to 6.32 with the ratio of the longest to the shortest 1.85; eighty-three percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as " 3A type". The first and the second pair of chromosomes carry an interstitial satellite. There is a second construction on the long arms of 8th pair of chromosomes.

(3) *N. sauluenensis* Balf. f.: The karyotype is formulated as 2n=24=4m (2SAT)+10st(2SAT)+10t. The relative lengths of chromosomes range from 12.55 to 6.13 with the ratio of the longest to the shortest 2.05; eighty-three percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized as " 3B type". The first pair of chromosomes carry an interstitial satellite and the 10th pair of chromosomes have a satellite on their short arms. A second construction was found on the long arms of 9th pair of chromosomes.

6. Notholirion Wall. ex Boiss

(1) *N. campanulatum* Cotton et Stearn: The resting nucleus are of the com-

plex chromocenter type and the mitotic prophase belong to interstitial type. The karyotype metaphase is formulated as 2n=24=2m (2SAT)+2sm+14st(2SAT)+6t. The relative lengths of chromosomes range from 12.07 to 6.47 with the ratio of the longest to the shortest 1.87; eighty-three percent of chromosomes have arm ratios over 2.00, and thus the karyotype asymmetry could be categorized to be "3A type". The first pair of chromosomes carry an interstitial satellite and the 10th pair of chromosomes have a satellite on their short arms.

The genus comprises four species, of which three are distributed in southwestern and northwestern China. The karyotype of *N. bulbiliferum* (Lingelsh.) Stearn. from Shaanxi is reported by Hsu et al. (1986) to be 2n=24=2m+2sm+20t with the ratio of the longest to the shortest chromosome 13.08, and the karyotype asymmetry is "3C type", which is different from that reported in this paper. In addition, no satellites were observed in his report.

From the results mentioned above, it is found that all of the first pair of chromosomes carry an interstitial satellite, and the karyotype asymmetry commonly belong to "3A type" (except *Nomocharis saluenensis* and *Notholirion bulbiferum*), indicating that the karyotypes of the Lilium, Nomochairs and *notholirion* are remarkably similar, which is concordant with the closely related relationships among three genera revealed based on the external morphology.

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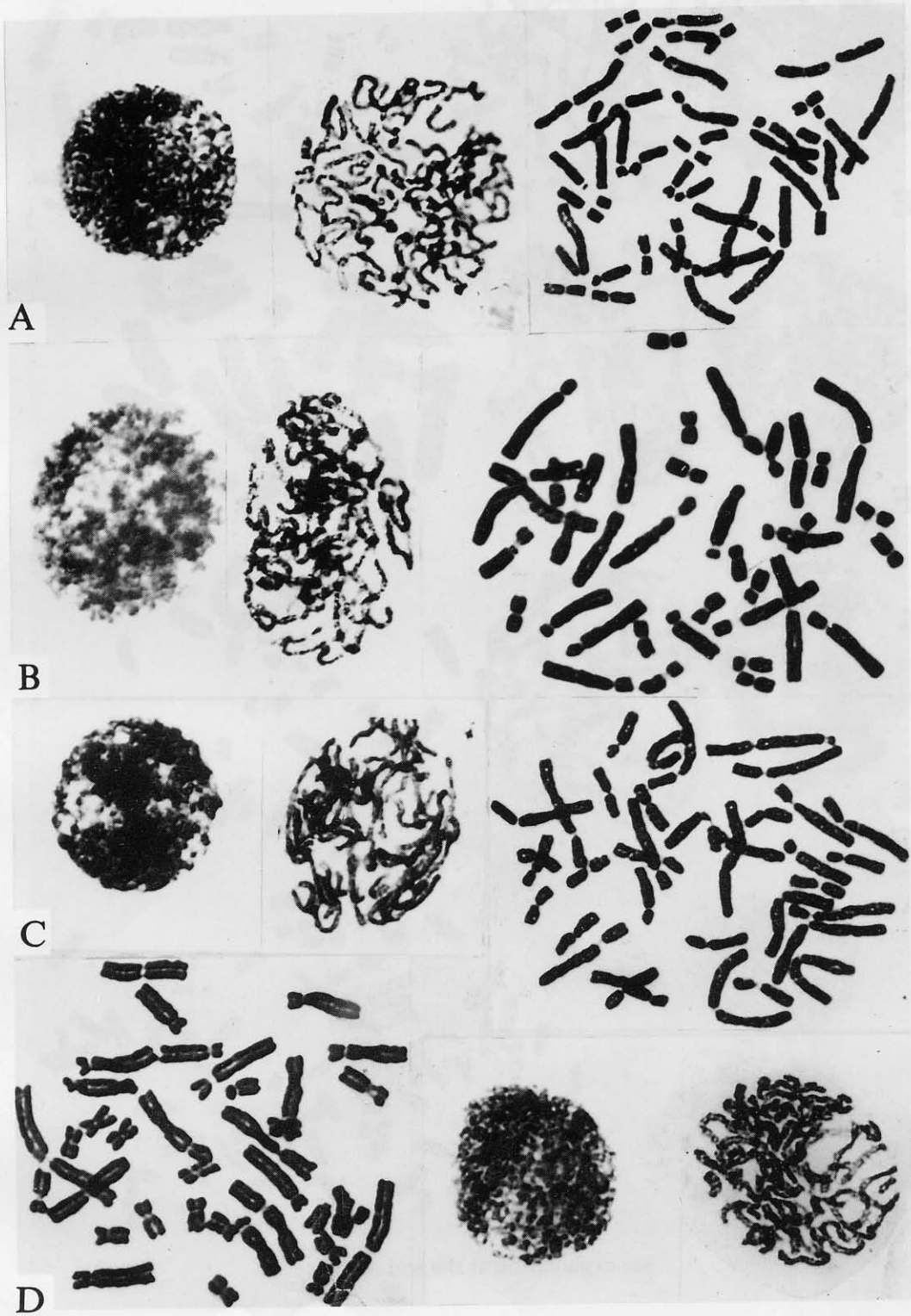
Explanation of plates

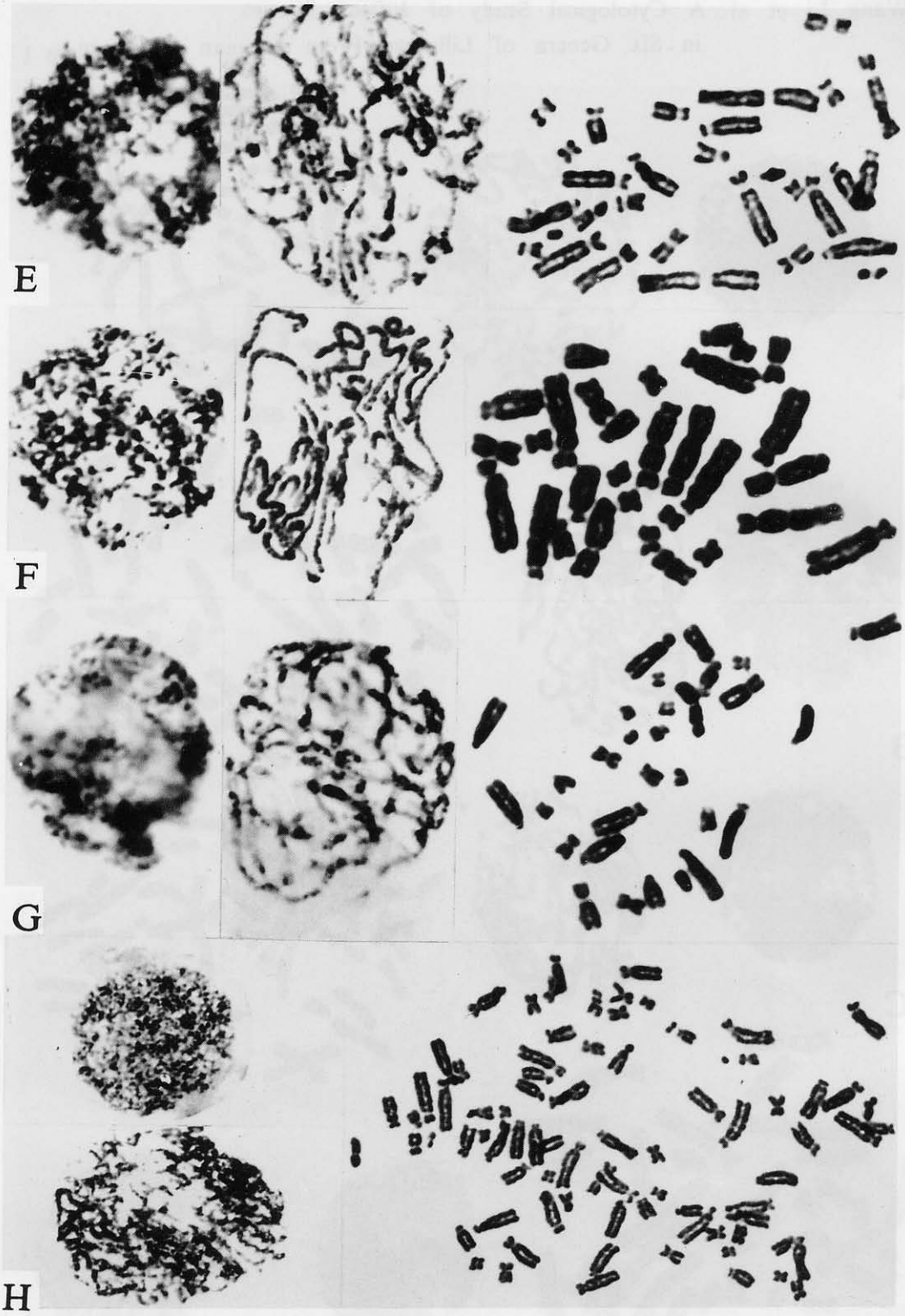
Plate 1 — 4 resting stage, mitotic prophase and metaphase of somatic cells of fifteen species in Liliaceae

Plate 5 — 7 Karyograms of fifteen species in Liliaceae

A. *Smilacina henryi*
B. *S. tatsienensis*
C. *S. fusca*
D. *S. atropurpurea*
E. *Polygonatum cathcartii*
F. *P. kingianum*
G. *P. cirrhifolium*
H. *P. curvistylum*
N. *N. bilouensis*
M. *Nomocharis pardanthina*
O. *N. sauluensis*
P. *Notholirion campanulatum*
Q. *Lilium henricii*
R. *L. bakerianum* var. *rubrum*
S. *Clintonia udensis*



see explanation at the end of text



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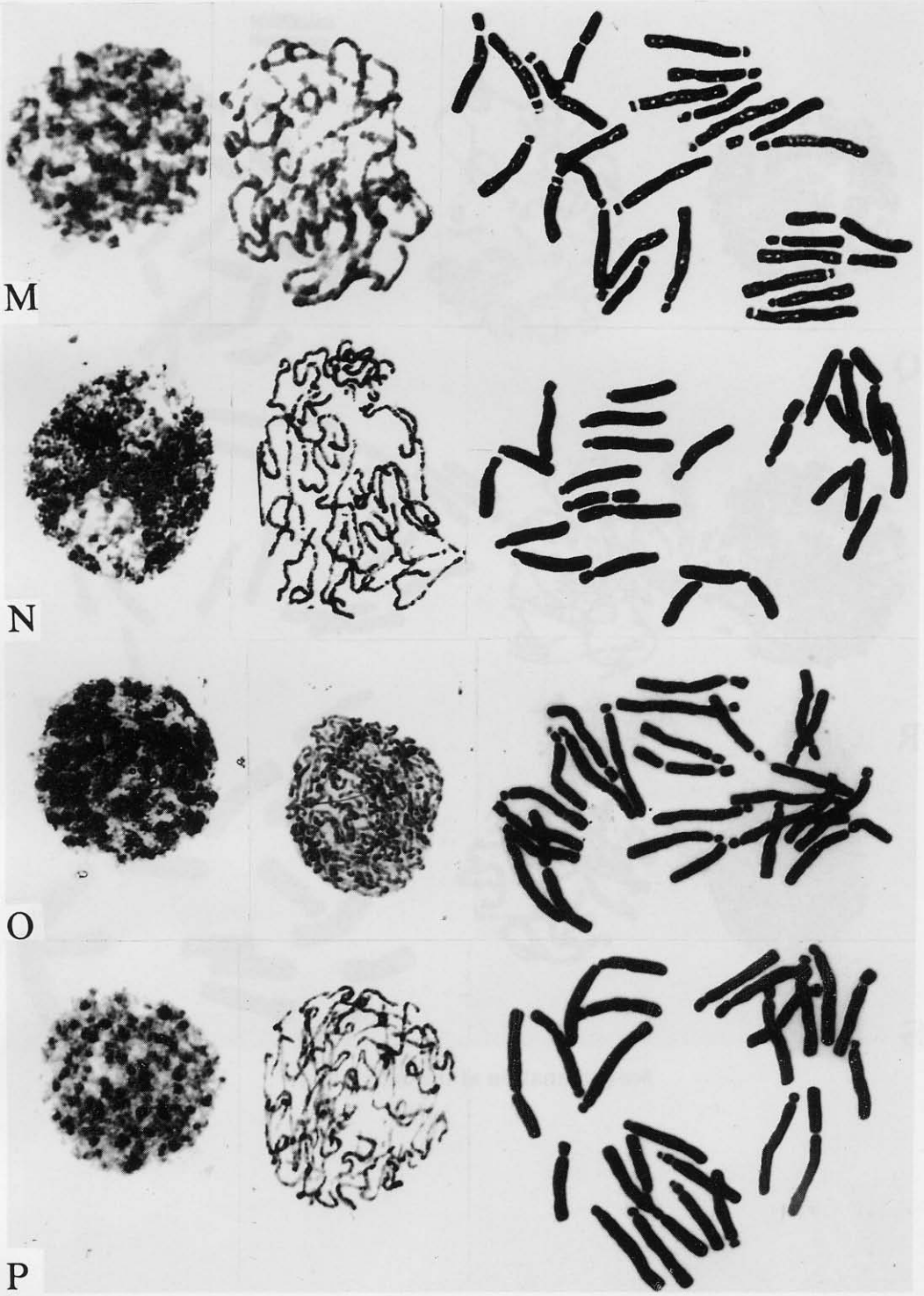

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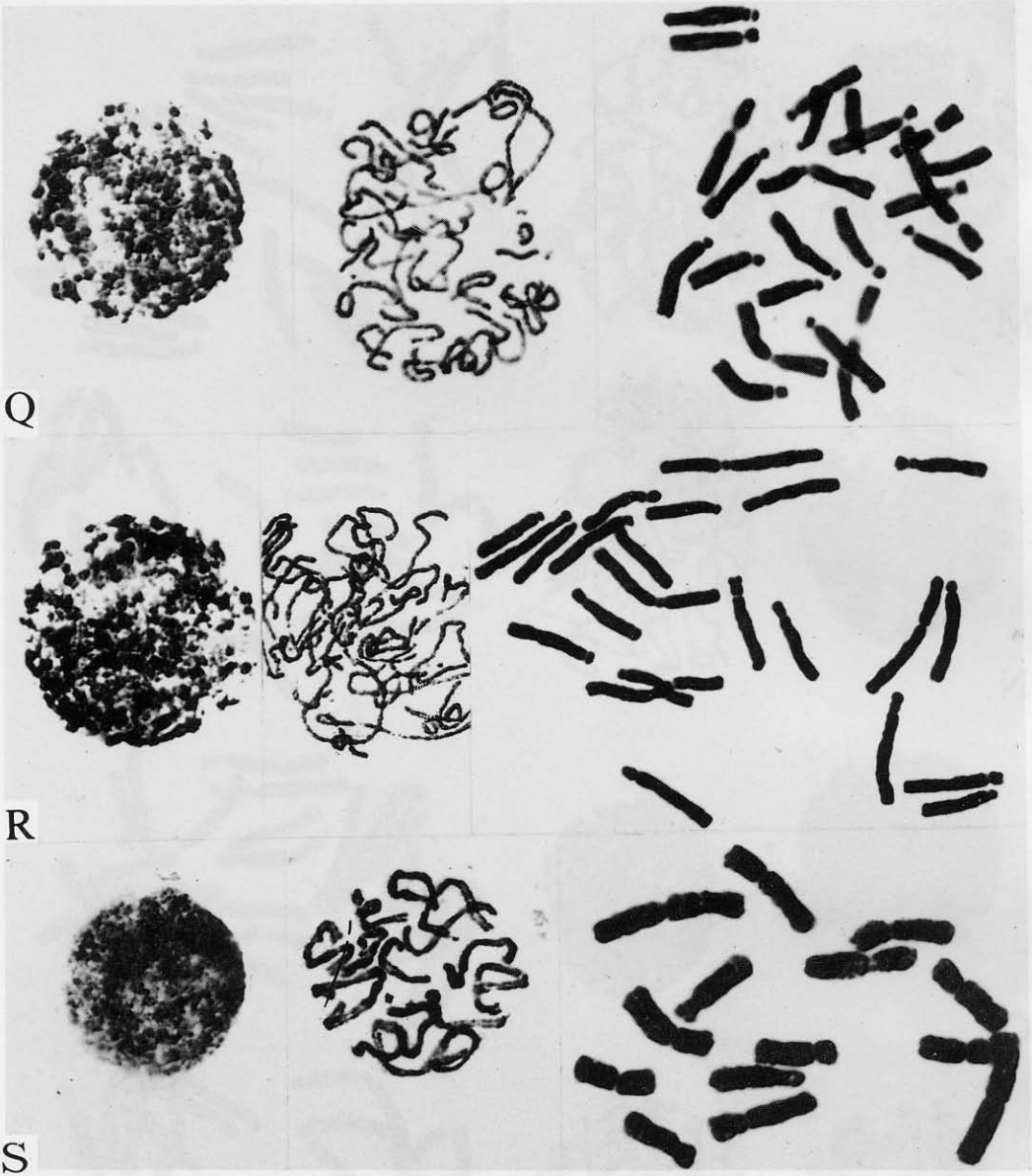

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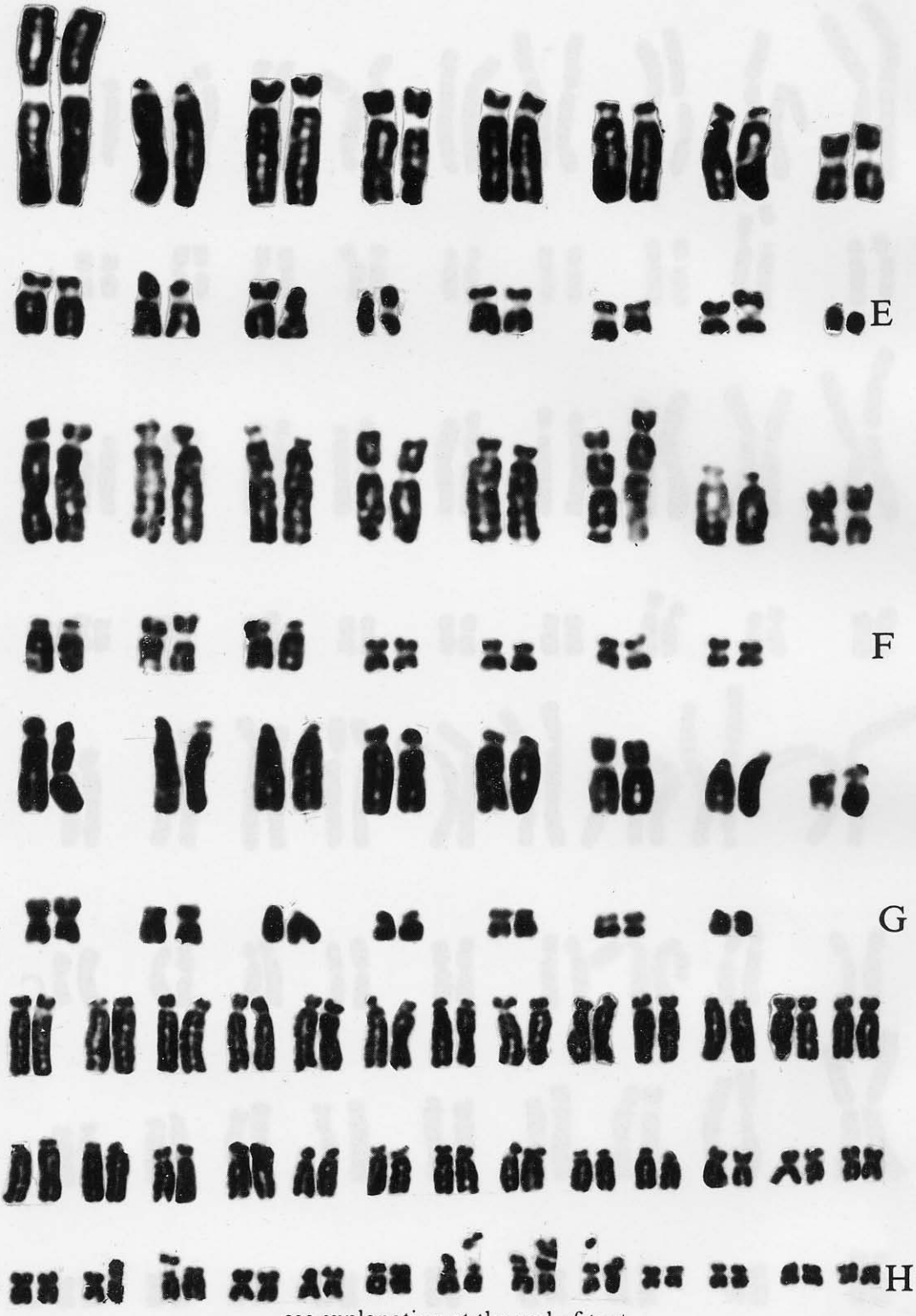

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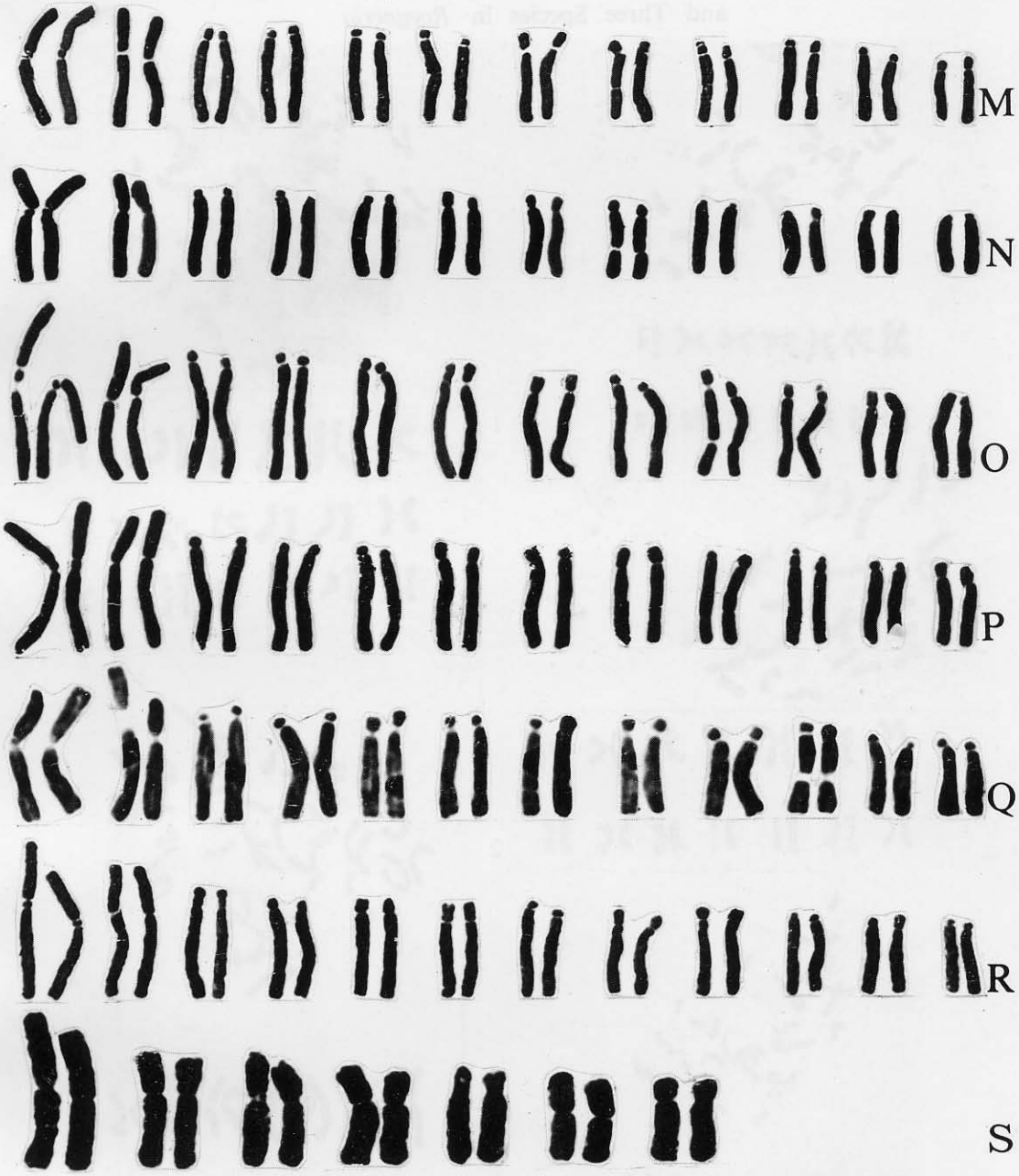

see explanation at the end of text